DEC STD 123-0 POWER CONTROL BUS STANDARD

DOCUMENT IDENTIFIER: A-DS-EL00123-00-0 Rev D, 21-Sep-1989

ABSTRACT: This standard defines the Digital power control bus function and its electrical and mechanical components.

APPLICABILITY: Design Engineers and System Installers are responsible for abiding by the requirements defined in this standard for all hardware released that interfaces with the power control bus.

STATUS: APPROVED 21-Sep-1989; type $ VTX SMC for expiration date.

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APPROVAL: This standard has been updated to incorporate clerical changes. The design guidelines for ac power controllers have been deleted and now appear in *DEC STD 002-1 Power Controller Units - General Requirements*. No other changes in the technical content have been made.

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CONTENTS

1 INTRODUCTION 1
1.1 PURPOSE 1
1.2 SCOPE 1

2 DEFINITIONS 2

3 DESCRIPTION 3
3.1 PURPOSE OF A POWER CONTROL BUS 3
3.2 FUNCTIONAL DESCRIPTION OF POWER CONTROL BUS 3
3.3 PIN IDENTIFICATION 3
3.3.1 Pin 1 - Power Request 3
3.3.2 Pin 2 - Power Inhibit (Formerly Emergency Shutdown) 3
3.3.3 Pin 3 - Return (Formerly Ground) 4
3.4 TRUTH TABLE FOR BUS LOGIC 7

4 BUS CONTROL SPECIFICATION 7
4.1 LEAKAGE TO CHASSIS 9
4.2 MASTER SWITCH OR SENSOR SHUTOFF DEVICES (TRANSMITTERS) 9
4.3 POWER CONTROL BUS INTERCONNECTIONS 9
4.4 EMI FILTERING PER DEC STD 103 9
4.5 SAFETY REQUIREMENTS 10
4.5.1 SELV Requirements 10
4.5.2 Fault Protection 10
4.5.3 Switched Power Selector (Formerly Local-Remote Switch) 10

5 CONFIGURATION 10
5.1 BUS LOADING 10
5.1.1 Configuration Requirements 11
5.1.2 Assumptions 11

6 IMPLEMENTATION 13
6.1 BRANCHING ABILITY 13
6.2 AC POWER CONTROLLER DESIGN GUIDELINES 13
6.3 POWER BUS SEQUENCERS AND REPEATERS 13
6.3.1 Power Bus Sequencers 13
6.3.2 Power Bus Repeaters 13

Appendix A REFERENCED DOCUMENTS 15

A.1 EL-Class Digital Documents 15

FIGURES

1 Power Control Bus Block Diagram 5
2 Power Control Bus System Interconnect 6
3 Boundaries for Allowed Bus Operations 8
4 Typical Control Bus System 12

TABLES

1 Pin Identification 3
2 Truth Table for Bus Logic 7
3 Requirements For Pin 1 or 2, Referenced to Pin 3 Return 7
4 Pin 1 or 2, Referenced to Pin 3 Return 9
5 Minimum Common Mode Insertion Loss Required for Each Wire Filter 9

1 INTRODUCTION

Since 1972, Digital has used a standard 3-wire power control bus to control power. Its purpose is to have the bus controls, master switch, and sensor shutoff devices (such as over temperature thermostats) turn on and off switched power in a predictable manner to a box, cabinet, or system of cabinets. Its original implementation was with ac power controllers, which used the bus for control and also allowed a single power entry to a cabinet, as required by DEC STD 119. It is now also used with other equipment such as battery backup and dc power controllers requiring this same type of control.

WARNING

The Digital power control bus cannot be relied on to remove hazardous voltages from the system.

1.1 PURPOSE

The purpose of this standard is to provide product designers and System Installers with information to design and connect equipment with the power control bus. It is not its purpose to define which equipment should use the bus.

1.2 SCOPE

This standard provides a specification of the power control bus and a description of its operation. It includes definitions, applications information, and descriptions of the components of the bus. It also includes configuration rules and specifications for power control buses. Design guidelines for ac power controllers are also included.

NOTE

Implementation of the Digital power control bus is intended to permit normal control of the power state of computers and certain peripheral devices. It is not intended to meet the requirements of National Fire Protection Association (NFPA) No. 75-7300 Emergency Power Controls in Computer Rooms. That specification requires an "Emergency Power Control Switch", located near the operator's panel and near the room EXIT, that disconnects all power to the electronics and air conditioners in the room. Digital recommends that the user provide such switches and protective circuitry as part of site preparation. To avoid confusion, the master switch of the power control bus will not be labeled "Power ON-OFF" or "Emergency Power Off". It could be labeled "Run-Standby" or an equivalent.

2 DEFINITIONS

Refer to Figures 1 and 2 when reading the following definitions.

daisy chain - Two connectors parallel-wired on a power control device that allow for the continuation of the power control bus in a straight line method.

branching - Three or more connectors parallel-wired on a power control device that allow the power control bus to interface with several other devices.

bus control - A device that responds to signals from the power control bus to activate or deactivate a power switch.

master switch - A device that controls the state of the power request circuit.

power control bus - A network made up of a master switch, power control cables, bus controls, and sensor shutoff devices interconnected according to the set of configuration rules established by this standard.

power control cable - A 3-wire cable used to interconnect the sensor shutoff devices, the master switch, and the bus controls.

power controller - A device typically containing a bus control, power source inputs, load power distribution, and a power switch activated by the bus control.

power request circuit - An electrical loop consisting of a current source/sense element, power control cable, and master switch using pins 1 and 3 of the power control bus to activate the power switch.

power inhibit circuit - An electrical loop consisting of a current source/sense element, power control cable, and sensor shut off devices, using pins 2 and 3 of the power control bus. When activated, this circuit overrides the effect of the power request circuit.

power switch - A device, activated by the bus control, that supplies or removes power to a load.

repeater - A circuit that creates an additional power control bus. The circuit passes onto the additional bus the power request and power inhibit signals appearing on the first bus.

sensor shutoff device - A device, such as an over temperature sensor, air sensor, or smoke detector, that controls the state of the power inhibit circuit.

sequencing - Delaying the power request signal before passing it to another bus control, also referred to as the delay bus.

switched power - Power that is activated or deactivated by the bus control.

system shield - A layer of electrically conductive material, enclosing a volume, that forms an electromagnetic boundary.

unswitched power - Power that is neither activated nor deactivated by the bus control. Unswitched power is present whenever source power is applied and the input circuit breaker is closed.

3 DESCRIPTION

3.1 PURPOSE OF A POWER CONTROL BUS

A power control bus provides a means of controlling the power state of a system from local or remote locations using low level, non-hazardous voltages.

A power control bus does not shut off all power to the equipment. For example, semiconductor memory refresh, clocks, and disks may remain on. A power control bus does not function as an emergency power off for the equipment. It does not remove power for the purpose of servicing equipment. Some hazardous circuits may remain energized. A power control bus may allow unexpected start-up, as in the case of operation by a self-resetting thermal sensor. The power control bus does not prevent fire, shock, injury, or function as a safety interlock. Refer to Figure 1, which is a power control bus block diagram.

3.2 FUNCTIONAL DESCRIPTION OF POWER CONTROL BUS

A bus control both supplies and detects power in response to sensors and a master switch. The detected power is used to control a power switch. A typical power control bus system interconnection diagram is shown in Figure 2.

If a sensor or master switch is open, a bus control must be capable of supplying all the leakage currents required by an entire system and interpret the condition as a high. If a sensor or master switch is closed, a bus control must supply current within specific limits and interpret the condition as a low.

3.3 PIN IDENTIFICATION

Refer to Table 1.

Table 1: Pin Identification

Pin 1	Power Request
Pin 2	Power Inhibit (formerly Emergency Shutdown)
Pin 3	Return (formerly Ground)

3.3.1 Pin 1 - Power Request

The state of Pin 1 is controlled by the master switch. Power is requested when the switch is closed, called a low on Pin 1.

3.3.2 Pin 2 - Power Inhibit (Formerly Emergency Shutdown)

The state of Pin 2 is controlled by sensor shut-off devices, any one of which may close to assert a low to inhibit power. Pin 2 shall not be asserted low during the course of normal operation to cause the removal of switched power.

3.3.3 Pin 3 - Return (Formerly Ground)

The states of Pin 1 and Pin 2 are referenced to Pin 3 (not to ground). Pin 3 may be grounded in old designs, but is not to be grounded in designs meeting this standard.

Figure 1: Power Control Bus Block Diagram

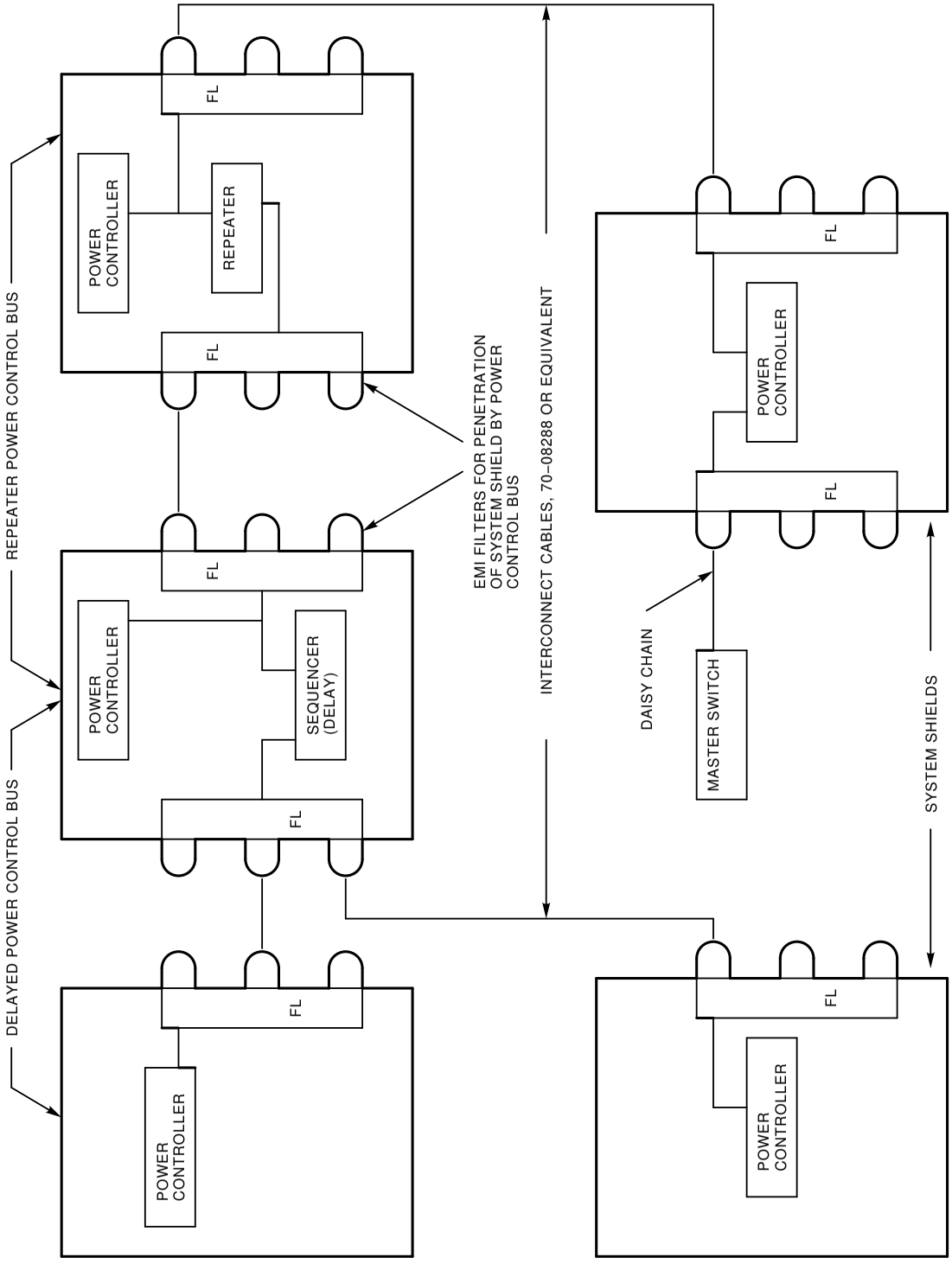
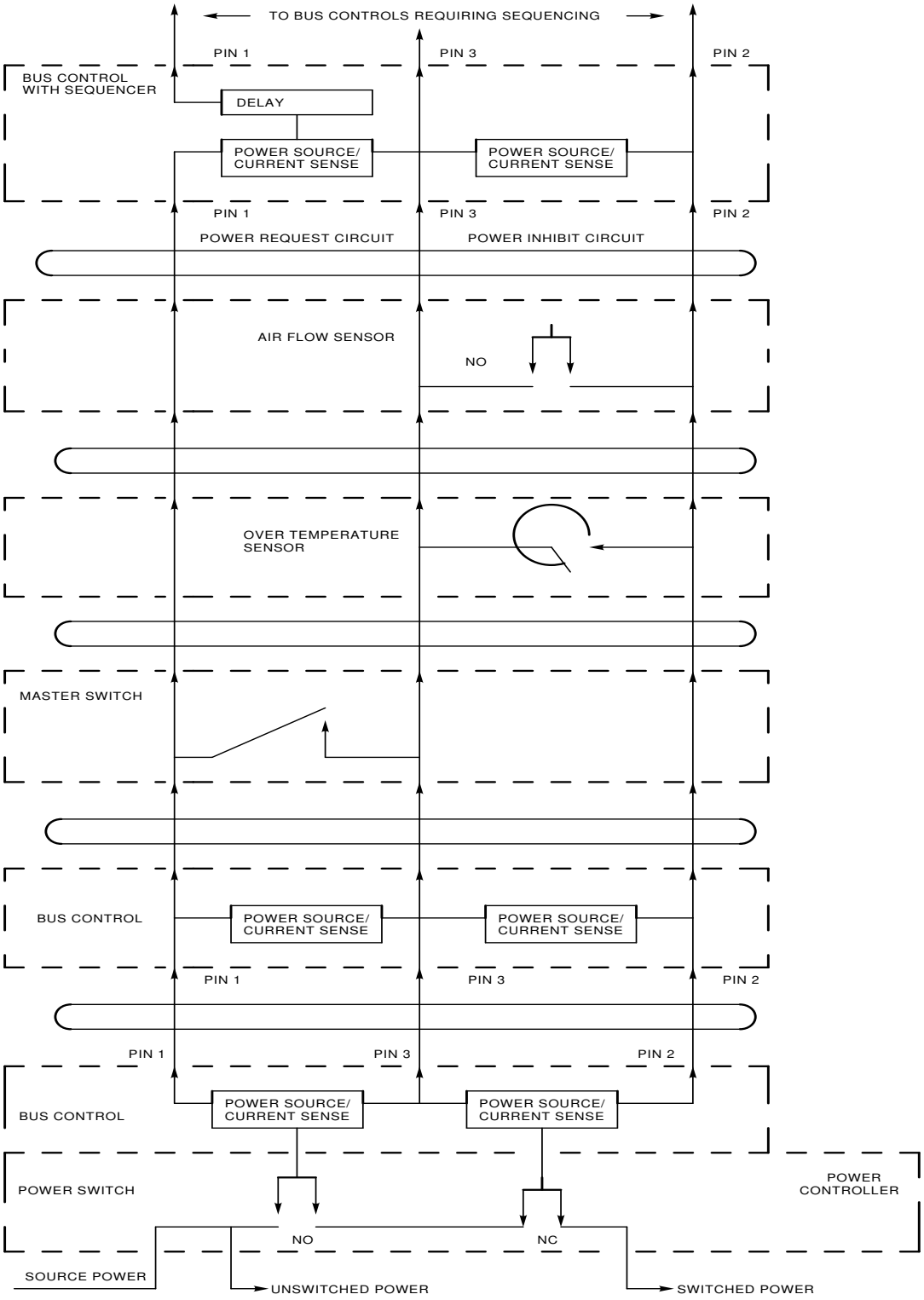


Figure 2: Power Control Bus System Interconnect



3.4 TRUTH TABLE FOR BUS LOGIC

Table 2: Truth Table for Bus Logic

	Pin 1	Pin 2	Switched Power
	High	High	OFF
	Low	High	ON
	High	Low	OFF
	Low	Low	OFF

4 BUS CONTROL SPECIFICATION

The two circuits, power request and power inhibit, should be treated independently. Bus control units are self-powering, contain a power supply of 35 volts or less, and conform to the truth table shown in Table 3.

Table 3: Requirements For Pin 1 or 2, Referenced to Pin 3 Return

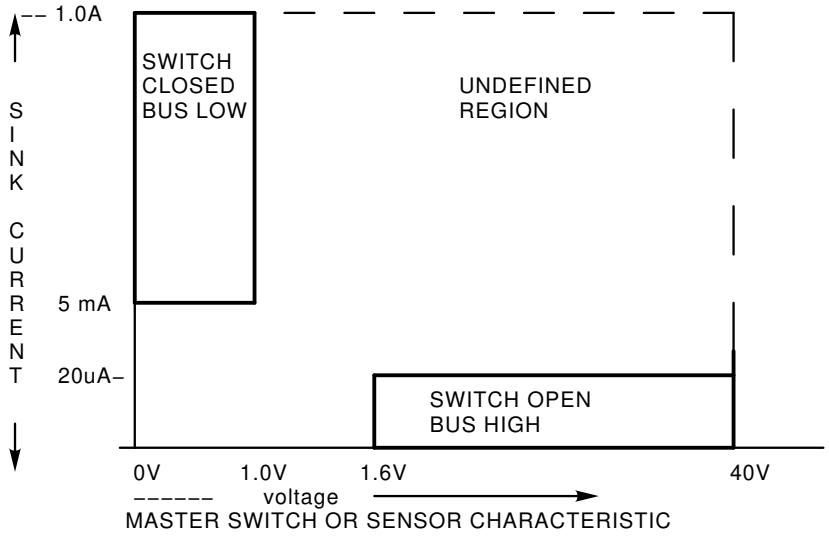
Interpreted as a Low:	Source current at least 5 mA but less than 25 mA with the bus voltage between 0 and +1.6 V.
Interpreted as a High:	Source current less than 1.0 mA and bus voltage more positive than +1.6 V.
Leakage Current:	Must sink less than 20 μA at a Vin of +40 V.
Open Circuit Voltage:	Shall be less than +35 volts when measured with a meter with at least 10 megohms input resistance.
Short Circuit Current:	Shall be at least 5 mA but less than 25 mA when shorted to return.
Transient Voltage:	A transition shall not cause a transient voltage on the power control bus of less than -0.7 volts or greater than +40 volts peak.

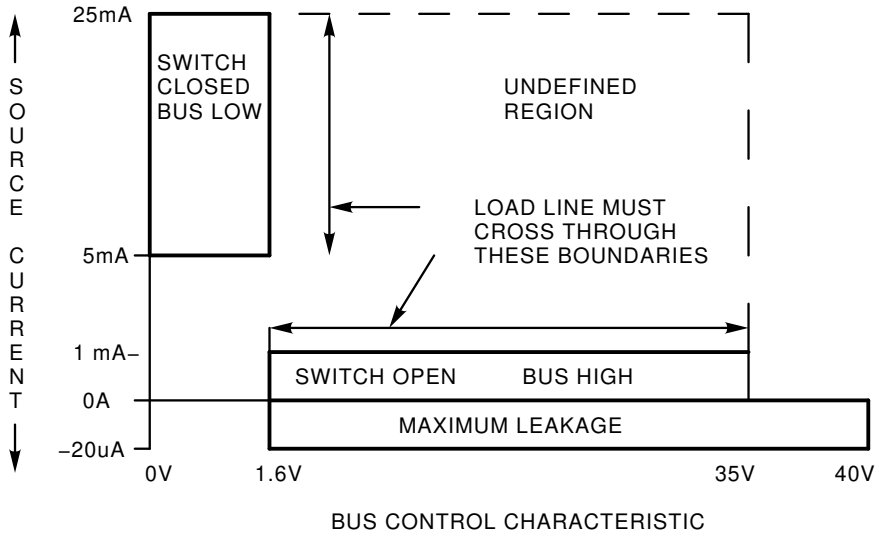
NOTE

Voltage to be interpreted as a high is dependent on the implementation and can range from 1.6 volts to 35 volts.

Figure 3 shows the boundaries for the allowed operations of the bus.

Figure 3: Boundaries for Allowed Bus Operations





4.1 LEAKAGE TO CHASSIS

Leakage to chassis for each device on the bus shall not exceed 0.5 mA at 40 V. To prevent the bus from floating to an abnormally high voltage, a resistor may be added between Pin 3 and chassis. A recommended resistor is a 47K 0.5 W +5%, Digital Part No. 13-01761-00.

4.2 MASTER SWITCH OR SENSOR SHUTOFF DEVICES (TRANSMITTERS)

Table 4: Pin 1 or 2, Referenced to Pin 3 Return

Switch Open:	Must sink less than 20 μA at a Vin of +40 volts whether powered or unpowered.
Switch Closed:	Must have a voltage drop of less than or equal to 1.0 volts when sinking a current of 1000 mA.

4.3 POWER CONTROL BUS INTERCONNECTIONS

The power control bus has three wires. The connector on the power controller is a Digital Part No. 12-09350-03 housing with Digital Part No. 12-09379-00 contacts or the equivalent.

The connectors on the power control bus cables are Digital Part No. 12-09351-03 housings with Digital Part No. 12-09378-00 contacts or the equivalent. Drawing No. 70-08288 gives details of a typical cable.

4.4 EMI FILTERING PER DEC STD 103

No device or part of the power control bus may in itself contribute emission in excess of DEC STD 103 requirements. If the power control bus penetrates the system shield and does not attenuate the EMI it has picked up, it may degrade the EMI shield effectiveness. Thus, each wire of the power control bus must be filtered at the point of its penetration of the system shield.

Table 5: Minimum Common Mode Insertion Loss Required for Each Wire Filter

Frequency	Insertion Loss
3 MHz	10 dB
30 MHz	30 dB
1000 MHz	30 dB

NOTE

Straight line interpolation is required between frequencies using semi-log plot.

The filter that meets these requirements is Digital Part No. 12-21099-01. This is a 3-wire filter with daisy chain capability.

4.5 SAFETY REQUIREMENTS

General safety requirements such as insulation, spacings, and enclosures may be found in DEC STD 119.

4.5.1 SELV Requirements

The power control bus is considered an operator-accessible circuit. All components, such as the master switch, power control cables, bus controls, and sensor shutoff devices must meet the SELV (Safety Extra Low Voltage) requirements of DEC STD 119.

4.5.2 Fault Protection

While operation of the power control bus may prevent or reduce equipment damage, its function is not a substitute for safety requirements found in DEC STD 119. It is not to be relied on to prevent fire, shock, casualty, or other safety hazards.

4.5.3 Switched Power Selector (Formerly Local-Remote Switch)

There may be a 3-position switch located on the power controller labeled "BUS, OFF, and ON". In the BUS position, the power control bus controls the operation of the switched power. In the OFF position, only that power controller is off and the controller will not respond to power control bus logic. In the ON position, the switched power from that controller only is distributed to its load regardless of the power request signal. If power inhibit is asserted, however, the controller must turn switched power off.

If the control switch is OFF or ON, the switch or wiring must be capable of passing the bus signals to other bus controls. The switch position must never affect the operation of another bus control.

5 CONFIGURATION

All devices, the bus controls, master switch, and sensors, are connected in parallel on the 3-wire bus. Not all devices make use of all wires, but all three are routed to each device by the power control cable. The configuration of the system may be a straight line, with the bus daisy chained from one device to the other, or a branching connection, where one device forms a node to which several others connect.

The maximum configuration is limited by several factors: the total current from the bus controls that the sensor or master switch must carry, the maximum leakage current allowed on the system, the voltage at the master switch or sensor when considered a low, the voltage at the bus control when considered a low, and the resistance of the power control cable. These constraints lead to the following limitations on the configuration of the bus system.

5.1 BUS LOADING

The following configuration guidelines are based on the assumptions in subhead 5.1.2. The system engineer can come up with alternate configurations based on different conditions. In lieu of directions from the design engineer, field and manufacturing personnel should follow these rules.

5.1.1 Configuration Requirements

When configuring a system, the following rules must be met:

Rule 1. The maximum number of bus controls must not exceed 40.

The limiting factor of 40 bus controls is based upon each bus control in the low state sourcing 25 mA of current and the master switch or a sensor being limited to 1 ampere (40 X 25 mA = 1 ampere of sink current. Leakage current is not a limiting factor in the low state when applying rule 1.

Rule 2. In the low state, the voltage at the bus control must not exceed 1.6 volts.

There may be 40 bus controls supplying 25 mA for a total of 1 ampere. The sensor is allowed to have a 1.0 volt drop at 1 ampere. This limits the drop in the cables to 0.6 volts with 1 ampere flowing. From this information, the following formula was derived to describe the limits of an acceptable cabling configuration:

$(L + 10)\ N \leq 480$

The symbol definitions and derivation are shown in subhead 5.1.2.

Rule 3. The maximum number of sensors and bus controls on a single power control bus is limited to 50.

This rule is based upon each device being allowed to sink 20 microamperes or to source 1 milliampere in the high state (greater than or equal to 1.6 V). This ratio of source current to sink current yields a maximum of 50 devices.

Refer to Figure 4 for the following example configuration.

5.1.2 Assumptions

The formula $R\ (L+A)\ IN \leq E$ was developed to determine the limits of an acceptable configuration, where:

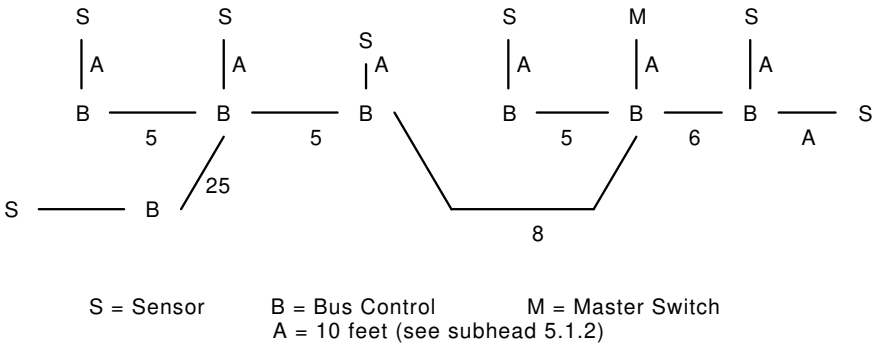
R = Cable resistance per foot
L = Cable length in feet between any two bus controls
A = Assumed maximum distance in feet between a bus control and either sensor or master switch within a cabinet
I = Maximum source current of any bus control (low state)
N = Number of bus controls
E = Interconnect voltage drop in volts due to cable resistance.

$R\ (L+A)\ IN \leq E$ can be reduced to $(L + 10)\ (N) \leq 480$ based on the following values:

R = 50 milliohms/foot
A = 10 feet
I = 25 milliamperes
E = O.6 volt

These values were derived as follows:

Figure 4: Typical Control Bus System



EXAMPLE

a. Number of Bus Controls = 7 — Meets Rule 1

b. (L + 10) N less than or equal to 480

L = 25 ft. + 5 ft. + 8 ft. + 6 ft. = 44 ft.
N = 7
(44 + 10) (7) = 378 less than or equal to 480 — Meets Rule 2

c. Number of bus controls and sensors = 14 — Meets Rule 3

The interconnect cable is assumed to be Digital Part No. 70-08288. This is 22 AWG wire, which has a resistance of .016 ohm/foot. Since the current path is twice the cable length, total resistance would normally be 2(.016) = .032 ohm/foot. However, the return conductor can carry twice the current due to contributions by both the power request and power inhibit circuits. This will result in twice the voltage drop along the return conductor. This is the equivalent of the return conductor being .032 ohm/foot and when added to the outgoing conductor resistance of .016 ohm/foot, gives an equivalent cable loop resistance of .048 ohm /foot. In the formula this resistance "R" is rounded to .050 ohm/foot.

The assumption was made that, within a single cabinet, the maximum length power control cable interconnecting the bus control with either a sensor or master switch is 10 feet. Therefore, 10 feet may be substituted for "A" in both the example and the formula.

Each bus control in the bus low state is limited to sourcing a maximum of 25 mA. Therefore, "I" becomes .025 ampere.

The maximum number of bus controls N is 40, based on the following assumptions. Each switch (sensor or master switch) is expected to handle a maximum of 1 ampere in the bus low state. Each bus control in that state is limited to sourcing 25 mA. The number of controls, N = Isw/Ibus = 1 ampere/.025 ampere = 40.

Any switch (sensor or master switch) is allowed a maximum voltage drop of 1 volt when closed. The voltage at the bus control must be no more than 1.6 volts under this condition to be interpreted as a low. This allows 0.6 volt for interconnect loss, which is assumed to be due to cable resistance. Therefore, "E" in the above formula = 0.6 volt.

6 IMPLEMENTATION

6.1 BRANCHING ABILITY

When designing power control bus devices, keep in mind that a device with a single connector will terminate that branch of the bus. In general, devices should have at least two connectors to allow daisy chaining. It is preferred, especially on power controllers, that three or more connectors be provided to permit branching.

6.2 AC POWER CONTROLLER DESIGN GUIDELINES

The information on input ac connections, filters, lamps, input protection, contactor rating, and total off control, formerly presented under this heading is now included in *DEC STD 002-1 Power Controller Units - General Requirements*.

The information on switched power selector switch functions is under Heading 4, Bus Control Specification.

6.3 POWER BUS SEQUENCERS AND REPEATERS

6.3.1 Power Bus Sequencers

A power bus sequencer is a circuit that adds a delay to the power request line (Pin 1). It helps prevents excessive inrush currents by allowing several products, such as disk drives, to start sequentially.

The sequencer receives its logic signal from the Digital power control bus and transmits the delayed signal via another connector that uses the same type cable as the power control bus. The power inhibit is paralleled in the connectors so the inhibit function is not lost.

To provide the user with configuration information, the product specification should include the time delay and the driving capability of the sequencer. On the product it should be clear which connection is to the undelayed power control bus and which connection is for the delayed bus.

6.3.2 Power Bus Repeaters

A repeater is a circuit that creates an additional power control bus, passing on to that bus the power request and power inhibit signals appearing on the first bus. Because the power inhibit signal cannot be passed from the second bus to the first without special arrangements to keep the two busses from locking each other in an off condition, the use of such a circuit is not recommended.

APPENDIX A

REFERENCED DOCUMENTS

A.1 EL-Class Digital Documents

EL-Class Number	Document Title
EL-00002-00	*DEC STD 002-0 AC Power Wiring, Safety Earth Grounding, Plugs and Receptacle Information and Requirements*
EL-00002-01	*DEC STD 002-1 Power Controller Units - General Requirements*
EL-00060-00	*DEC STD 060-0 Design and Certification of Hardware Products to National and International Regulations and Standards*
EL-00103-00	*DEC STD 103-0 Electromagnetic Compatibility (EMC) Hardware Design Requirements*
EL-00119-00	*DEC STD 119-0 Digital Product Safety*
EL-00186-00	*DEC STD 186-0 Signal Integrity*

Copies of Digital EL-Class documents may be obtained from Standards and Methods Control, $ VTX SMC, JOKUR::SMC, DTN: 234-4423, or NRO4/D4.

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